Passive Autonomous Acoustic Monitoring of Marine Mammals: System Development Using Seaglider™

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Award Number: N00014-10-1-0515

LONG-TERM GOALS

A group within the Applied Physics Laboratory of the University of Washington (APL-UW) dedicated to the use of autonomous underwater vehicles in support of Navy missions executed this program. The group generally uses the Seaglider™, developed at APL-UW, and develops or adapts instruments and glider behavior to support specific mission requirements. This group is informally called the Applied Seaglider Group, whose acronym (ASG) is also used to describe the mission-adapted Seaglider itself.

This report describes ongoing efforts as part of the ONR Passive Autonomous Acoustic Monitoring (PAAM) program. The original long-term goals of the PAAM program were as follows.

- Perform persistent and autonomous passive acoustic monitoring of a 500-1000 square nautical mile Navy exercise area for presence of marine mammals.
- Monitor for three weeks prior to, three weeks during, and three weeks after a typical exercise.
- Detect, classify and localize (DCL) vocalizing marine mammals.
- Provide actionable information in a timely manner to the officer in tactical command to support marine mammal mitigation efforts.

Over the past several years, the long-term goals of the ONR PAAM program have changed to concentrate on the DCL mission in support of monitoring of marine mammals, particularly in Navy operating areas. In particular, a primary goal is to provide a persistent (many months) marine mammal monitoring capability in Navy operating areas that are remote or difficult to monitor by traditional means. These include the Hawaii, Gulf of Alaska, and Mariana Islands operating areas.

OBJECTIVES

With previous ONR funding (N00014-08-1-0309), we have enhanced the passive acoustic detection, recording, and on-board processing capabilities of the Applied Seaglider (ASG), with particular attention to the automated detection of beaked whale echolocation clicks. In particular, we have

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
30 SEP 2013		**00-00-2013 to 00-00-2013**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Passive Autonomous Acoustic Monitoring of Marine Mammals: System Development Using Seaglider	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **University of Washington,Applied Physics Laboratory,1013 NE 40th St,Seattle,WA,98105**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**Same as Report (SAR)**	**4**	

designed and built a new passive acoustic detection and recording system for ASG, and tested this system in the field several times.

The objectives of this program are to successfully demonstrate the single-channel acoustic recording system in a long-duration mission in a relevant Navy operating area, enhance the on-board detection and classification software, and to investigate the utility of multiple hydrophones.

This is the last year of this program, and funding was nearly exhausted conducting our Washington coast mission in summer, 2012. So our objectives for FY2013 were to support any data analysis performed by our colleagues Drs. Mellinger and Klinck at Oregon State University, to incorporate lessons learned from our summer 2012 deployment in plans for future monitoring missions, and to ensure a way forward so that other investigators could acquire and operate the Seaglider PAAM system.

APPROACH

The program originally was focused on automated detection, classification, and recording of beaked whale vocalizations. Over the life of the PAAM program, however, the Navy's needs shifted from real-time notification for mitigation to long-term monitoring to support permit applications and meet environmental compliance requirements.

Our approach was as follows.

- Treat the single-hydrophone PAAM electronics system as deployed at AUTEC in June, 2010, and at SCORE in January, 2011, as a baseline.
- Execute long-duration (greater than one month) missions.
- Investigate installation of multiple hydrophones and suitable re-configuration of the electronics.
- Continue to collaborate with Drs. David Mellinger and Holger Klinck at Oregon State University (OSU) on improved detection and classification algorithms and on the scientific utility of multiple hydrophone installations.

Geoff Shilling (software engineer) and Sean Lastuka (electrical engineer) were key participants at APL-UW, in addition to the Principal Investigators listed above. Drs. David Mellinger and Holger Klinck at OSU provided detection and classification algorithms and data analysis.

WORK COMPLETED

No additional field work was completed during FY2013.

One of the lessons learned from the Washington coast field deployment in summer, 2012, was that the PAAM electronics board storage management system needed to be modified for enhanced reliability. So Revision B of the PAAM electronics boards were given initial check-out. This revision accommodated a switch from USB-based data storage to Micro Secure Digital High Capacity cards (uSDHC). The move should make the PAAM storage management system simpler and more reliable, as uSDHC cards only need to be mounted once, written until full, then umounted. The next card in line would then be mounted, and so on. Multiple mounts and unmounts of the cards, as was required

in the USB-based system, would not be needed. A total of eight (8) uSDHC cards are available for data storage on the Revision B PAAM electronics boards. Current uSDHC maximum capacity is 64GB, for a total of 512GB of storage.

Revision B of the PAAM electronics boards will be used in the operational monitoring phase of the Seaglider PAAM project.

RESULTS

No additional field results were obtained. Some preliminary planning for operational monitoring missions was done. Initial check-outs of Revision B to the PAAM electronics boards was accomplished.

Drs. Klinck and Mellinger of OSU were responsible for data analysis from the summer 2012 Washington coast deployment. They were able to successfully process the recorded acoustic time series, despite the presence of substantial cable noise in one system.

The following resulted from their analysis.

Talk:
Klinck, K., Mellinger, D. K., Matsumoto, H., Bogue, N. M., Luby, J. C., and Stelzer, R. (2013): Gliders, floats, and robotic sailboats: a review of recent advances in mobile autonomous passive-acoustic platforms. Sixth International Workshop on Detection, Classification, Localization, and Density Estimation of Marine Mammals using Passive Acoustics, 12-15 June 2013, St. Andrews, Scotland.

Poster:
Fregosi, S., Klinck, H., Mellinger, D. K., Bogue, N. M., and Luby, J. C. (2013): Acoustic observations of mid-frequency cetaceans in the eastern North Pacific using a glider. Sixth International Workshop on Detection, Classification, Localization, and Density Estimation of Marine Mammals using Passive Acoustics, 12-15 June 2013, St. Andrews, Scotland.

IMPACT/APPLICATIONS

The Seaglider/PAAM detection and recording system has achieved an initial operational capability with a single omni-directional hydrophone. Although several problems appeared in our long-duration mission, we think they are surmountable with the hardware and software changes needed for the Revision B electronics board.

Once the Revision B PAAM electronics boards are fully checked-out and tested locally, we will be ready to undertake a series of two-month demonstration missions in Navy operating areas under Pacific Fleet control.

On 23OCT2012, the iRobot Corporation publicly announced that they intended to close their Maritime Systems operations in North Carolina and immediately stop production of the Seaglider. In response to this unexpected announcement, the University of Washington initiated the process to terminate the Seaglider manufacturing license held by iRobot.

On 16MAY2013, Kongsberg Underwater Technology, Inc., of Lynnwood WA, announced that they had successfully completed negotiations with the University of Washington to obtain the sole rights to produce, market, and continue the development of the Seaglider. Kongsberg Underwater Technology, Inc., plans to deliver their first production Seagliders in January, 2014, but has the capability to deliver special orders sooner.

We are still ready to build and install the PAAM system into Seagliders for researchers outside of our APL-UW development group. Seagliders themselves would have to be supplied, of course, from an investigator's existing research stock, or through purchase from Kongsberg Underwater Technology, Inc., the UW-licensed manufacturer. We will provide quotes on request from interested investigators. Either co-PI listed at the top of this report can respond to such requests.

We are also ready to build, integrate, and install the PAAM system into other oceanographic or sampling systems. In this case, there will be non-recurring hardware- and software-engineering charges, in addition to the fabrication, installation, and test costs.

It is important to note that we treat the Seaglider/PAAM system as a U.S. export controlled item, both under the Department of State's ITAR and the Department of Commerce's EAR programs. We will only provide the PAAM system to verifiable U.S. persons, in situations where no export license is required. It will then be the responsibility of the purchasing investigator to remain in compliance with all applicable export control regulations.

RELATED PROJECTS

The primary related project was the previous ONR-funded PAAM work, under N00014-08-1-0309, as mentioned above. That project performed the initial PAAM development, and carried out four major sea trials, including short deployments at both AUTEC and SCORE. It ended on 30APR2011.
There are many related projects to use passive acoustics on autonomous platforms to detect, classify, and monitor marine mammals; some are funded as part of ONR's broader PAAM program, some are supported elsewhere.

Dr. David Mellinger at OSU is directly funded by ONR under the PAAM program to provide beaked whale detection and classification algorithms. Dr. Mellinger and his colleague Dr. Holger Klinck also provide consultation on various other aspects of the Seaglider™/PAAM system.